Impacts of Legalization of Recreational Marijuana on Alcohol Sales: Economic Substitutes or Complements?

Honors Undergraduate Thesis

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Abstract

In 2012, Colorado and Washington became the first two states in the United States to legalize recreational cannabis. Since then, eight more states voted to recreationally legalize cannabis. One of the prime reasons cannabis has been legalized in many states is because of the tax revenue that it creates for each state. For example, Colorado's Department of Revenue has reported nearly one billion dollars in tax collections since the state started reporting marijuana tax collections in February of 2014. States could not only use the tax revenue in a myriad of ways for government-run programs that increase jobs, but states could also save billions of taxpayers' dollars in drug enforcement costs. However, the recreational legalization of marijuana has potential unintended impacts on the consumption of other goods available in the market, such as alcohol. Using data reported by states that have legalized recreational marijuana, crowd-sourced transaction data, and various other sources, this paper analyzes the relationship between marijuana and alcohol, attempting to determine whether or not the two substances are economic substitutes or complements. By progressing knowledge in this area of research, legislators and executives from the marijuana and alcohol industries could gain a more comprehensive understanding of the implications of marijuana legalization policies. In addition, it is essential to develop forecasts of growth and demand for the marijuana and alcohol industries to improve both industry-wide, and firm-level decision making.

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Introduction

Since 2012, ten states have legalized marijuana for recreational usage. The following states are included in the recreational legalization movement: Colorado, Washington, Alaska, Oregon, California, Nevada, Maine, Massachusetts, Vermont, Michigan. Each of these states has earned millions of dollars in tax revenue from the implementation of excise and sales taxes on marijuana and alcohol, which have been used in various ways to operate government programs. As marijuana and alcohol continue to be popular substances demanded by consumers in the United States market, relevant parties will have an increased interest in understanding whether the two substances are economic substitutes or complements. It is important to note that the macroeconomic relationship between the two substances is still in a very immature stage as marijuana has been legalized for recreational usage since 2012, as previously stated, meaning that transaction and price data have been tracked for a brief period of time, which limits this paper's scope of research. As a result, states have difficulty accurately reporting and measuring relevant data and statistics.

My findings may be valuable for legislators attempting to comprehensively understand the markets of each of the substances, tobacco companies that are interested in expanding their businesses into marijuana sales, marijuana-related businesses such as dispensaries and growers, as well as alcohol companies that are trying to understand the impact that marijuana has upon the alcohol industry. Alcohol and beer manufacturers are considering infusing cannabidiol (a cannabis compound credited with having various medical benefits) into alcoholic beverages. For example, Constellation Brands, the producer of popular beers such as Corona and Modelo, have invested $4 billion into

Canopy Growth Company, a Canadian cannabis producer. Publicly traded corporations that are prevalent in the marijuana business include AbbVie Inc, Scotts Miracle-Gro Co, Cronos Group Inc., Constellation Brands, and Canopy Growth Co. Each of these companies were analyzed to estimate the future growth of the marijuana industry.

Although marijuana and alcohol are two distinct substances, many people believe that the substances are used in similar ways recreationally. In this analysis, the relationship between alcohol and marijuana was evaluated using the economic measure, cross price elasticity, which shows whether the two substances are economic substitutes, complements or independent of each other based on the recreational price of marijuana and quantity demanded of alcohol provided by state-operated commissioning and reporting entities.

Literature Review

There is a plethora of research studying the impact of marijuana legalization, both medically and recreationally, on alcohol usage. It is important to note the distinction between recreational marijuana and medical marijuana because many researchers have established conclusions about the relationship, but ultimately found contradictory conclusions based on which form of marijuana was analyzed. For example, Amanda Reiman concluded that alcohol and marijuana are substitutes for medical marijuana patients based on anonymous survey data that she collected (Reiman, 2009). The researchers that evaluated the relationship between marijuana and alcohol highlighted the importance of updating their research in the future because of lack of data, economic policy changes, as well market changes (Crost, 2013), (Guttamanova, 2015), (Williams,

2004). Demographic information is another significant variable studied by many researchers in determining conclusions about the relationship between marijuana and alcohol. For instance, Thomas Dee thoroughly studied demographic factors such as age, race, and gender in his analysis, “The Complementarity of Teen Smoking and Drinking.”

One of the most comprehensive works in this field was completed by Katarina Guttmannova. Her paper references over forty papers relevant to this topic. Within the paper, there is a section titled “Recommendations for Future Research.” The paper strongly recommended to investigate “between-state comparisons” using the difference-in-difference research approach. In the same section of this paper, the researcher suggested that a time series approach will allow us to “assess whether passage of a marijuana-related policy is associated with deflections off prior trajectories of substance use outcomes over time.” These two types of analyses should be completed in the future to understand how the markets of marijuana and alcohol are changing over time. Guttmannova emphasized that there is an abundance of significant demographic and economic variables that go into the research on the topics of marijuana and alcohol. Guttmannova emphasized the importance of repeating past research analyses on a periodic basis to ensure that the understanding of the relationship between marijuana and alcohol remains current.

Researchers, Jenny Williams and Benjamin Crost, developed contradicting conclusions in regard to establishing whether alcohol and marijuana are substitutes or complements. Jenny Williams was able to show that marijuana and alcohol have a complementary relationship based on data provided from the Harvard School of Public Health’s College Alcohol Study on college students. Williams’ research focused on

demographic factors that related to the two substances' relationship such as gender, race, and age. On the contrary, Benjamin Crost showed that the substitution effect between alcohol and marijuana is stronger for women than for men (Crost, 2012). Benjamin Crost and Daniel Rees have proven that the minimum legal drinking age law causes an increase in the consumption of illicit drugs, especially by young women. Additionally, the consumption of marijuana decreases sharply at the age of 21, while consumption of alcohol increases. In Crost's paper, the researchers did not disclose whether their data came from states that have legalized recreational marijuana or not. It would be interesting to see if the states sampled and studied would change their concluding results, especially after a number of years of recreational legalization of marijuana in many states.

Hypothesis

Based on the current state of research on this topic, there is equivocal information determining if alcohol and marijuana are substitutes or complements. Additionally, many researchers conclude that the two markets, alcohol and marijuana, are independent of each other. Thus, one market does not influence the other market. There are a number of variables that influence the datasets provided by each state that have legalized marijuana. Some of these factors include, but are not limited to tourism, the minimum legal drinking age, gender, race, population growth, cost of goods, taxes, and government regulations. Even though past researchers have established conflicting conclusions regarding the relationship between alcohol and marijuana, I hypothesize that the legalization of recreational marijuana has hindered alcohol sales in the states that have

legalized recreational marijuana. Thus, alcohol and marijuana are substitutes for each other.

Methodology

Cross-price elasticity is an economic concept that measures the responsiveness in quantity demanded of one good when the price of another good changes, which shows if the goods are substitutes, complements, or independent of each other. Obtaining relevant and reliable data to use in the cross-price elasticity analysis was challenging because many states that legalized recreational marijuana did not report enough data necessary to complete the analysis. Washington, Alaska, California, Maine, Vermont, Michigan are the states that did not provide enough data. Washington, California, Vermont, and Michigan did not provide the appropriate data for recreational marijuana prices in order to conduct the cross-price elasticity analysis. Alaska only provided information on tax collections from sales, but not the price of the actual sales. In addition, Maine provided sales data on medical marijuana, not recreational marijuana. Thus, cross-price elasticity was used on four out of ten states that legalized recreational marijuana. The four states analyzed were Colorado, Oregon, Nevada, and Massachusetts. After analyzing monthly, quarterly, semi-annual, and annual reports to find the available data for marijuana market prices of bud from each of these states, quantities demanded of alcohol (measured in gallons) were compiled from government-run entities. Quantity demanded of alcohol and marijuana market prices were compiled from the following entities: the Colorado Department of Revenue, State of Nevada Department of Taxation, Oregon Liquor Control Commission, Massachusetts'

Department of Revenue and Cannabis Control Commission. Finally, once the data was assorted and compiled properly, cross-price elasticity was able to be calculated for the four applicable states.

As previously stated, the relationship between alcohol and marijuana was evaluated using the economic measure, cross-price elasticity. In this particular analysis, as the market price of recreational marijuana changed, the responsiveness in quantity demanded of alcohol was measured, which gives us the resulting cross-price elasticity measure of the two substances. The equation for cross-price elasticity is shown in **Figure 1** of the Appendix. But, before conducting the analysis it was imperative to understand the meaning of the result of the cross-price elasticity calculation. A positive cross-price elasticity results in supporting evidence for economic substitutes, which means that marijuana and alcohol are used to replace one another. As the cross-price elasticity result is increasing away from "0", the relationship between the two goods becomes increasingly strengthened, which provides evidence in support of a substitutable relationship. For example, if two goods have a cross-price elasticity of "5", then they will have a stronger substitutable relationship than two goods with a cross-price elasticity of "1". This result would prove the hypothesis to be true by showing the two goods to be substitutes. A negative number provides evidence of a complementary relationship, marijuana and alcohol are used to perfect each other. The more negative the cross-price elasticity value is, the stronger support is for a complementary relationship. Two goods with a cross-price elasticity of "-5" are regarded as more complementary than two goods with a cross-price elasticity of "-1." A result of 0 would mean that the two substances are independent of

each other. The marijuana market does not impact the alcohol market. As the price of marijuana rises, the quantity demanded for alcohol remains constant.

Once the cross-price elasticity was calculated for each reporting period of the states that legalized recreational marijuana, the results needed to be analyzed further to increase the significance of the result. Short-term consumer sentiment was integrated into the analysis by developing the statistic, “Average Cross-Price Elasticity” (ACPE). The ACPE was calculated by taking the average of all of the cross-price elasticity results from each reporting period for a particular state. The ACPE represents short-term consumer sentiment because each time the price of marijuana changes over a specific reporting period, the quantity demanded of alcohol was measured for the same time period, resulting in a value for cross-price elasticity. For example, if the ACPE resulted in a negative number representing Colorado’s marijuana and alcohol markets, then the data shows that consumers in this state would likely purchase less alcohol when the price of marijuana increases, exhibiting complementarity of the two substances. In this example, the data is showing evidence of a complementary economic relationship between marijuana and alcohol, which might be signifying that the consumers in this market have less disposable income to purchase alcohol as a result of the price increase in marijuana.

Although this research is mainly focused on the relationship of the two markets in the short-run, it is still important to comprehend the relationship of the two markets over the long-run. Thus, the statistic representing the long-run relationship of the marijuana and alcohol markets is a calculation of cross-price elasticity from the initial reporting period to the last documented reporting period. For example, Colorado provided sufficient data to begin calculating cross-price elasticity on January 1, 2014 until October 1, 2018,

the most recent reporting period for the Colorado Department of Revenue. The long-term statistic is less significant than the short-term cross-price elasticity calculation because economies change drastically over long periods of time, such as four years for Colorado. The short-term statistic that displays data that was collected from a monthly, quarterly, or semi-annual report can be relied upon much more than the long-term statistic because less external, economic factors are impacting the results in the short-run.

The median cross-price elasticity was calculated for each of the four states that provided sufficient data. The median serves as an indicator for the distribution of a dataset. When the values of cross-price elasticity are organized from lowest to highest values, and the mean and median are the same, the dataset is approximately evenly distributed. If the mean and median are different, then the data is likely asymmetrical that displays a skew to the left or a skew to the right.

Data Analysis

The Colorado Department of Revenue collected and reported data on the average market rates for marijuana and the quantities demanded of alcohol. **Figure 2** represents the cross-price elasticity results for each reporting period from Colorado from January 1, 2014 until October 1, 2018. The ACPE for Colorado for this time period is -4.0. Therefore, the data shows that marijuana and alcohol have a complementary relationship in the short-term. Contrarily, over the long-term, the Beginning to End of Reporting Period Statistic resulted in “0.0”. As previously stated, a “0” cross-price elasticity means that the two goods, alcohol and marijuana, are independent of each other. A change in the price of marijuana does not change the quantity demanded for alcohol. The median cross-price

elasticity over Colorado's eleven reporting periods is -0.9, displaying a weak complementary relationship. The median for Colorado is much smaller than the mean because the cross-price elasticity for the October 1, 2017 reporting period was -38.8. Conclusively, Colorado's data features a weak complementary relationship in the short-term, and an independent relationship in the long-term.

Figure 3 displays the results of the cross-price elasticity analysis for marijuana and alcohol conducted for Oregon from December 1, 2016 until December 31, 2018. There were 13 reporting periods over the three-year timespan. The ACPE for Oregon was -4.2, which shows that the two substances have a strong, complementary, short-term relationship. The long-term statistic for Oregon resulted in "0.0". Once again, showing that the two substances are independent of each other over the long-term. The median cross-price elasticity for the same time period was -2.9. It's important to note that the median and ACPE are negative values are precise. This means that the data reported by Oregon represents a moderately-strong, complementary relationship for marijuana and alcohol in the short-term, yet an independent relationship in the long-term.

Nevada reported sufficient and appropriate data to calculate cross-price elasticity over the reporting period from July 1, 2017 to July 1, 2018. Although Nevada reported sufficient data, the resulting cross-price elasticity calculation is not as significant as the other three states included in the analysis because there was only one cross-price elasticity calculated as a result of Nevada only two reporting periods. Nevada's only cross-price elasticity calculation resulted in a "0.0" value, featuring an independent relationship in the short-term and the long-term. Therefore, the median value for the state of Nevada is 0.0, too.

Massachusetts' cross-price elasticity calculations are exhibited in **Figure 3**. Massachusetts' reporting period is from November 1, 2018 to January 31, 2019. There were three reporting periods over this timespan, resulting in two cross-price calculations. ACPE and the Median cross-price elasticity equaled -2.7. The Beginning to End of the Reporting Period was -1.3. Therefore, both, the short-term statistic and long-term statistic illustrate a moderately-strong complementary relationship during the reporting period.

Another way that the data was analyzed was through descriptive statistics, which shows whether or not the findings for a particular state are statistically significant. The null hypothesis states that alcohol and marijuana are independent of each other, $H_o = 0$. As a result of the analysis, Colorado is the only state that provides a statistically significant result. In **Figure 6** the lower and upper bound are -11.85 and -8.34, respectively. Since 0 is not within the 95% confidence interval, there is statistical evidence that shows that the relationship that exists between alcohol and marijuana is not independent. Therefore, the null hypothesis could be rejected. It could be established that Colorado has a statistically significant complementary relationship for alcohol and marijuana. **Figures 7, 8, and 9** show that the data is not statistically significant, the null hypothesis was unable to be rejected because zero falls within the 95% confidence interval. Thus, the three states, except for Colorado, show that an independent relationship is a possibility at the 95% confidence level. **Figure 10** exhibits the descriptive statistics from the sample that contains all four states' cross-price elasticity calculations. The result from the compilation sample shows that the null hypothesis is unable to be rejected, which means that an independent relationship is a possibility that exists between the two substances at the 95% confidence level.

Results

The summary table in **Figure 5** shows the results of the cross-price elasticity calculations conducted for the three different statistics for each of the four states included in the analysis. As shown, the ACPE for three out of four states show a complementary relationship in the short-term that is between moderately-strong to strong. Even though the ACPE showed a complementary relationship, Colorado is the only state that exhibits a statistically significant relationship that is not independent. Thus, Colorado's results for cross-price elasticity support that there is evidence of a complementary relationship. Nevada is the only state that showed evidence of an independent relationship in the short-term, but it is also the only state that reported enough data to only calculate one cross-price elasticity calculation. Therefore, Nevada needs to provide more data over time to have enough data to represent a significant cross-price elasticity result. Nevada, Massachusetts, and Oregon do not provide a statistically significant conclusion in rejecting the null hypothesis, thus the relationship of the two substances within these states remains independent at the 95% confidence level. In the long-term, the only state to provide evidence of a complementary relationship was Massachusetts. The three other states showed that marijuana and alcohol have an independent relationship in the long-run as a result of the Beginning to End of Reporting Period statistic. In conclusion, the relationship between alcohol and marijuana remains independent, except for Colorado which provides evidence in support of a complementary relationship. The hypothesis stating that the two substances are used as economic substitutes appears to be incorrect based on the analysis of the data provided.

Future Research

This research analysis should be conducted on an annual basis to understand how the relationship between alcohol and marijuana changes over time. Changes in the economic environment occur constantly, which affect consumption, supply, and demand for the alcohol and marijuana markets. For instance, regulation changes by the government could have a dramatic effect on the consumption of alcohol and marijuana. If the minimum legal drinking age changed to eighteen years old, then there would likely be an increase in quantity demanded of alcohol. It's important for states that have already legalized recreational marijuana to track the prices of retail marijuana over time. Reporting inaccuracies and insufficiencies make it difficult to not only comprehend the data reported on the state-operated websites, but also difficult to find because each state has a different entity commissioning and reporting sales data for liquor and recreational marijuana. If marijuana becomes recreationally legalized at the federal level, a federal program should be created to report information about the two substances. A new government-operated program would not only increase the number of jobs in the economy, but it would also develop a sustainable, homogenous, record-keeping system for each state that facilitates research and analysis. The future drug-scheduling of marijuana may also have an impact on consumption levels of not only marijuana, but alcohol, too. Currently, marijuana is a Schedule I drug, which means that it is not safe to be used for medical trials. If marijuana becomes a Schedule III drug, comprehensive medical trials may be conducted pertaining to the drug. Depending upon whether the conclusions developed from the medical trials are positive or negative, consumption of marijuana could dramatically change.

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Figure 1: Cross Price Elasticity Formula

$$Cross\ Price\ Elasticity = \frac{\%\ \Delta\ in\ Quantity\ Demanded\ of\ Alcohol}{\%\ \Delta\ in\ Price\ of\ Marijuana}$$

Figure 2: Colorado Cross-Price Elasticity Over Time (1/1/14-10/1/18)

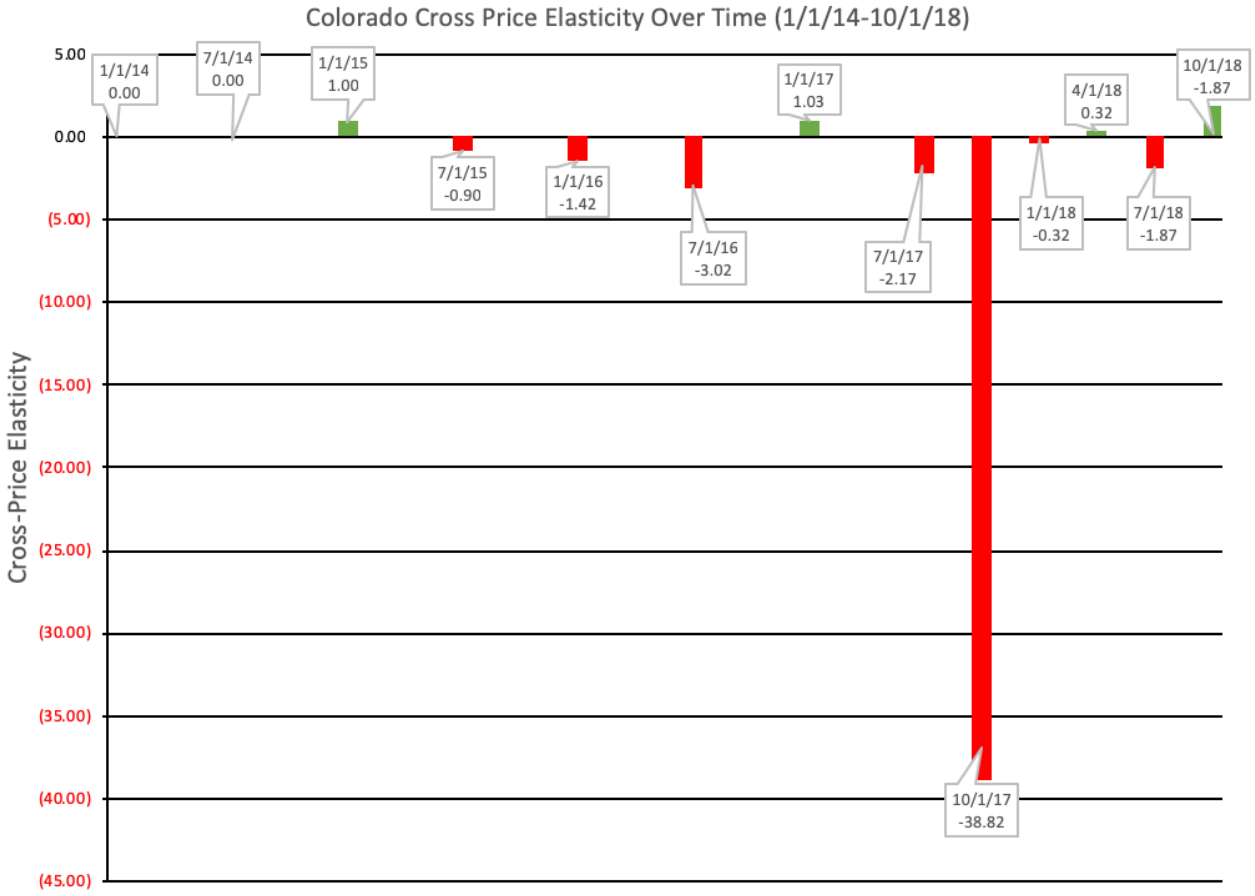

Figure 3: Oregon Cross-Price Elasticity Over Time (12/1/16-12/1/18)

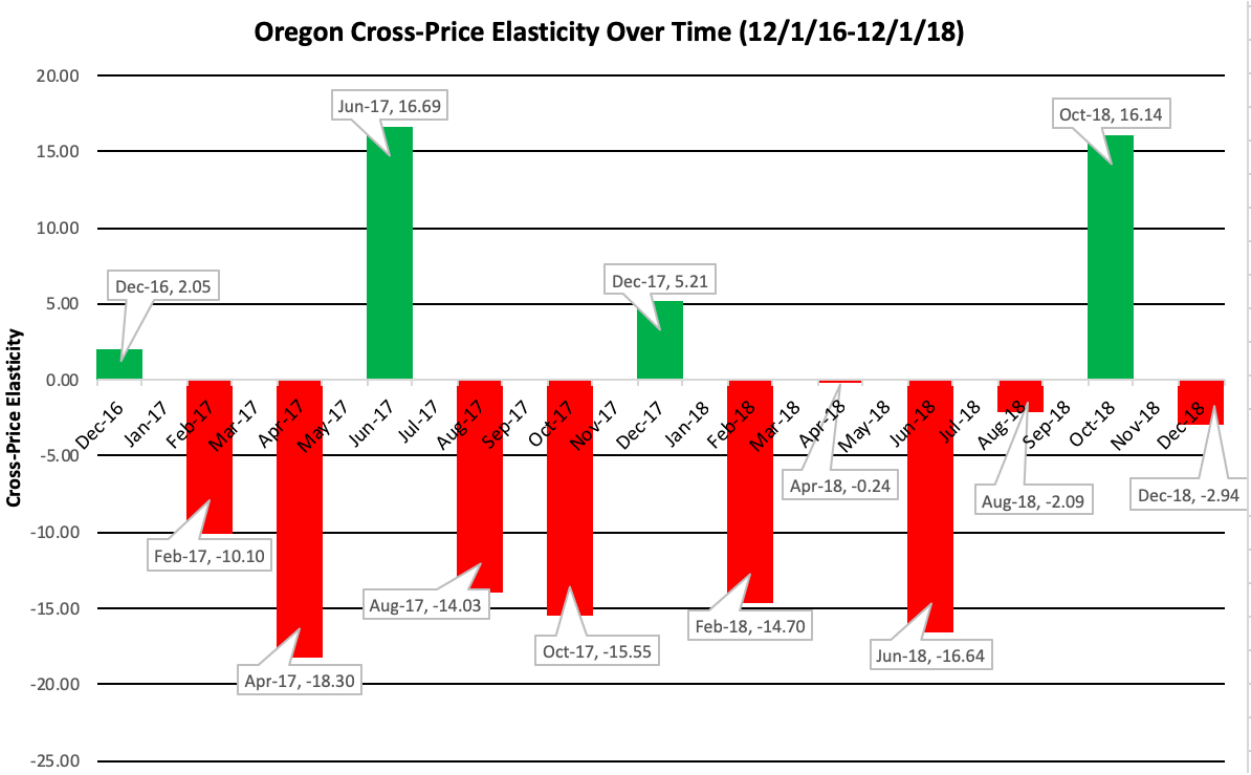

Figure 4: Massachusetts Cross-Price Elasticity Over Time (12/1/18-1/31/19)

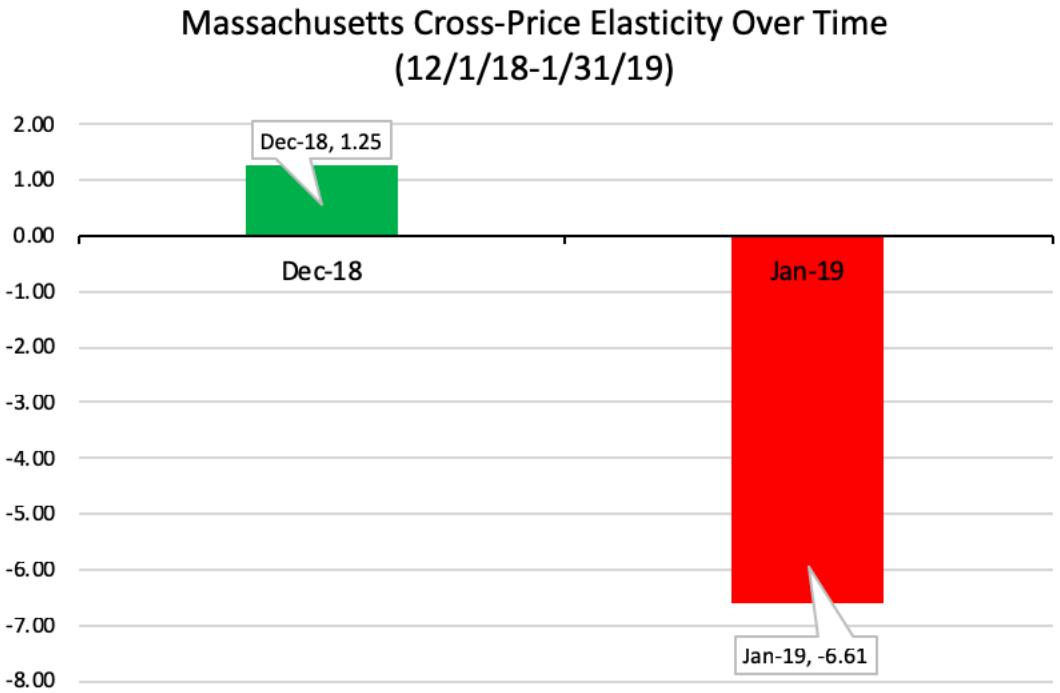

Figure 5: Cross-Price Elasticity Calculations Summary Table

State	Date	Average Cross Price Elasticity	Beginning to End of Reporting Period	Median Cross-Price Elasticity
Colorado	1/1/14 - 10/1/18	**-4.0**	**0.0**	**-0.9**
Oregon	12/1/16 - 12/31/18	**-4.2**	**0.0**	**-2.9**
Nevada	7/1/17 - 7/1/18	**0.0**	**0.0**	**0.0**
Massachusetts	11/1/18 - 1/31/19	**-2.7**	**-1.3**	**-2.7**

Figure 6: Colorado Descriptive Statistics

Colorado Descriptive Statistics	
Mean	-4.03
Standard Error	3.51
Median	-0.90
Mode	#N/A
Standard Deviation	11.64
Sample Variance	135.49
Kurtosis	10.51
Skewness	-3.21
Range	40.70
Minimum	-38.82
Maximum	1.88
Sum	-44.30
Count	11.00
Confidence Level(95.0%)	7.82
Lower Bound	-11.85
Upper Bound	-8.34

Figure 7: Oregon Descriptive Statistics

Oregon Descriptive Statistics	
Mean	-4.19
Standard Error	3.32
Median	-2.94
Mode	#N/A
Standard Deviation	11.98
Sample Variance	143.63
Kurtosis	-0.76
Skewness	0.58
Range	34.99
Minimum	-18.30
Maximum	16.69
Sum	-54.50
Count	13.00
Confidence Level(95.0%)	7.24
Lower Bound	-11.43
Upper Bound	3.05

Figure 8: Nevada Descriptive Statistics

Nevada Descriptive Statistics	
Mean	0.04
Standard Error	0.00
Median	0.04
Mode	#N/A
Standard Deviation	#DIV/0!
Sample Variance	#DIV/0!
Kurtosis	#DIV/0!
Skewness	#DIV/0!
Range	0.00
Minimum	0.04
Maximum	0.04
Sum	0.04
Count	1.00
Confidence Level(95.0%)	#NUM!

Figure 9: Massachusetts Descriptive Statistics

Massachusetts Descriptive Statistics	
Mean	-2.68
Standard Error	3.93
Median	-2.68
Mode	#N/A
Standard Deviation	5.56
Sample Variance	30.87
Kurtosis	#DIV/0!
Skewness	#DIV/0!
Range	7.86
Minimum	-6.61
Maximum	1.25
Sum	-5.36
Count	2.00
Confidence Level(95.0%)	49.92
Lower Bound	-52.60
Upper Bound	47.24

Figure 10: Summary Descriptive Statistics

Summary Descriptive Statistics (4 States Combined)	
Mean	-3.86
Standard Error	2.11
Median	-1.42
Mode	#N/A
Standard Deviation	10.97
Sample Variance	120.35
Kurtosis	3.18
Skewness	-1.06
Range	55.51
Minimum	-38.82
Maximum	16.69
	-104.12
Count	27.00
Confidence Level(95.0%)	4.34
Lower Bound	-8.20
Upper Bound	0.48

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